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Transducer Preparation and Gage Assembly of the Bureau of Mines Three-Component Borehole Deformation Gage

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8764

Transducer Preparation and Gage Assembly of the Bureau of Mines Three-Component Borehole Deformation Gage

By David L. Bickel

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UNITED STATES DEPARTMENT OF THE INTERIOR
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CONTENTS

	Page
Abstract	1
Introduction	1
Part 1--Borehole gage transducer preparation	2
Materials	2
Summary of strain gage installation	3
Description of strain gage installation	4
Part 2--Assembling the three-component borehole gage	12
Materials	12
Description of borehole gage assembly	13
Recommendations	18
References	19

ILLUSTRATIONS

1.	Tapered fit transducer	6
2.	Trimming the strain gage	6
3.	Handling the strain gage and terminal	6
4.	Preparing the strain gage for placement on the element	6
5.	Placing the strain gage on the element	6
6.	Clamping technique	8
7.	Preparing the element for epoxying the strain gage and terminal	8
8.	Lathe dog clamp showing element location for heat curing	8
9.	Cutting strain-gage wires to the correct length	10
10.	Transducer showing solder locations	10
11.	Test jig assembly	10
12.	Apparatus for testing transducer resistance	10
13.	Female connector and hookup wires	15
14.	Transducer location and color code	15
15.	Wiring diagram for one component in the three-component borehole gage	15

TRANSDUCER PREPARATION AND GAGE ASSEMBLY OF THE BUREAU OF MINES THREE-COMPONENT BOREHOLE DEFORMATION GAGE

by

David L. Bickel[1]

ABSTRACT

The following instructions and descriptions are presented in two parts to assist an individual to make the borehole deformation gage transducer, and to assemble and test the three-component borehole deformation gage. This Bureau of Mines three-component borehole deformation gage (4, 8, 11)[2] fits in a 1-1/2-in-diameter borehole that is drilled in rock and then overcored to determine rock stress.

INTRODUCTION

Calibration and operating procedures, together with the design of the Bureau of Mines three-component borehole deformation gage (5), have made this gage a reliable tool for determining in situ field stress. Overcoring deformation measurements (6, 9, 12), and rock anisotropy (1-2, 7) determined from biaxial (3) and triaxial (10) testing of the drilled core, are used to calculate in situ rock stress.

All materials for the three-component borehole gage and the instrumentation equipment are commercially available.

This report is divided into two parts. The first part of the report describes the fabrication of the transducer, the cantilever element of the borehole gage. The second part of this report describes the construction of the three-component borehole deformation gages. The illustrations showing gage wiring may be helpful when changing a transducer or determining the location of an electrical malfunction or short circuit.

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[1]Physical scientist, Denver Mining Research Center, Bureau of Mines, Denver, Colo.

[2]Underlined numbers in parentheses refer to items in the list of references at the end of the paper.

PART 1--BOREHOLE GAGE TRANSDUCER PREPARATION

Materials

The following materials are essential to the fabrication of borehole gage transducers. It is advisable to have all the listed items at hand before starting the installation of the strain gage.

Transducer--Cold-worked beryllium copper, half-hard, 3/8-in-diameter rod (such as Beryco 33-25)[3] is recommended for the transducer material. Approximately 18 inches of rod is needed for six transducers plus two spares.

Strain gages--The Bureau recommends a strain gage with a constantin alloy grid that is temperature-compensated for beryllium copper (the approximate thermal expansion coefficient of beryllium copper is 9 ppm/° F), fully encapsulated in glass-fiber-reinforced epoxyphenolic resin and has two high-endurance lead wires. The size of the strain gage should be one-eighth inch long and 120 ohms resistance. It is an advantage to have the resistance of the strain gage marked on each strain gage envelope, for reasons that will be explained later in this report.

Degreasing agent--Two solvents, chlorothene or trichloroethylene, are recommended for degreasing the transducer and tools.

Terminal strips--The size of the terminal should be one-eighth to three-sixteenths inch long and approximately one-sixteenth inch wide.

Adhesive--A two-component, 100 pct solids epoxy adhesive designed for strain gage application, such as Micro-Measurements' M-Bond AE-15 or Armstrong A-2.

Spring clamps--Hargrave spring clamps, size 1, are recommended. A lathe dog clamp can be used (see step 19).

Pads and backup blocks--Two Teflon, two silicone gum, or two semihard rubber pads approximately three-thirty-seconds inch thick, along with two metal backup blocks large enough to cover the strain gage and terminal, are needed for each clamp.

Vise--A small bench vise with aluminum or copper soft jaws is recommended.

Glass plate--A flat surface, such as a glass plate 3 by 3 inches or larger, is used. The lid of a jar may be substituted for the glass plate.

Gauze sponges--Gauze sponges can be purchased commercially or made from cheesecloth.

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[3]Reference to specific companies or brand names is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

Cotton-tipped applicators--Gauze sponges can be used satisfactorily in place of cotton-tipped applicators.

Self-adhering Teflon or Mylar tape--Ideal width for this tape is one-half inch. Nonadhesive Teflon sheeting is required if rubber pads are used with the spring clamps instead of the Teflon pads or silicone gum pads.

Tools--Obtain either a strain gage applications kit or the following tools:

1. Sharp-pointed tweezers,

2. Self-closing or locking tweezers,

3. Dental probe (straight point preferred),

4. Surgical shears or scissors,

5. X-Acto or equivalent knife,

6. Wire strippers.

In addition, obtain the following equipment:

7. Soldering station or a temperature-controlled soldering iron,

8. Solder--A rosin-type flux core solder such as Micro-Measurements' No. 430-20S 0.020-in-diameter solid tin-silver solder,

9. Rosin solvent.

Summary of Strain Gage Installation[4]

This summary lists principal operations necessary to install the strain gage and can be used as a quick reference for the strain gage installation procedure.

1. Clean the element.

2. Prepare the gaging area of the element.

3. Etch the element.

4. Prepare terminal strips.

5. Trim the strain gage and pair the gages according to resistance.

6. Position the gage and terminal on the element.

---

[4]Numbers in the summary do not necessarily correspond to the step numbers in the "Description of Strain Gage Installation" section.

7. Prepare the clamp(s).

8. Mix the adhesive.

9. Cement the gage and terminal in place.

10. Clamp the cemented gages.

11. Heat cure the adhesive.

12. Clean the element and strain gage leads.

13. Solder the gage leads to the terminal.

14. Check the transducer for short circuits and continuity.

15. Conduct creep tests and postcure if necessary.

16. Test all transducers for resistance value and pair them.

17. Wire six transducers (three pairs) into the borehole gage body.

18. Gage is now ready for calibration (5).

Description of Strain Gage Installation

This description of the strain gage installation should be followed closely to insure a nearly creep-free transducer.

Step 1.--Cleaning the transducer element is the first and probably the most important step for strain gage installation. The degreasing agent currently being used is trichloroethylene. Trichloroethylene is toxic and should be used with adequate ventilation.

a. Scrub the element surface with a cotton-tipped applicator or a gauze sponge soaked with trichloroethylene.

b. Wipe the surface with a single motion using a clean piece of gauze moistened with trichloroethylene. Care must be taken not to touch the element until the strain gage has been cemented to the element and heat-cured. It is important that all tools that come in contact with the element or the strain gage, including the vice to hold the element, be cleaned with trichloroethylene.

Step 2.--If the epoxy resin adhesive is very viscous (such as Armstrong A-2), sandblast both flat surfaces of the element with clean alumina or silica (80 to 100 grit is preferred). The air supply should contain filters to remove oil from the air compressor. The grit should not be recycled. For an adhesive of light viscosity (such as M-Bond AE-15), sandblasting equipment is not necessary. Instead, follow these steps:

a. Dry-lap (sand the surface until a new color appears) the gaging area with silicon-carbide paper of 220 or 320 grit.

b. Apply a metal conditioner and wet-lamp (sand the surface lightly but thoroughly) the gaging area.

c. Remove the residue by slowly wiping the surface with a gauze sponge.

d. Apply a liberal amount of neutralizer and scrub the surface with a cotton-tipped applicator. Do not allow the neutralizer to completely evaporate, since this would leave a thin film between the adhesive and the element.

e. Remove the neutralizer with a gauze sponge by slowly wiping the surface with a single motion.

Step 3.--Etch the element by immersion (keep the element moving in the solution) in the following solution for 1-2 min at room temperature:

15 ml ferric chloride (42 pct solution),
30 ml concentrated nitric acid,
197 ml water (distilled).

Followed by thoroughly rinsing with distilled water and air-drying. Etching the element should follow shortly after the sandblasting.

It should be noted that the surface of beryllium copper will oxidize. Therefore, it is important to position and cement the strain gages on the element within 1 hour after the element has air-dried. Etch only the quantity of elements that can be clamped.

Step 4.--Secure the element in the vise (use soft jaw to protect the threads of the element) at the threaded end with a flat side up, as shown in figure 1.

Step 5.--Clean a glass plate or the lid of a jar with trichloroethylene and place it near the vise.

Step 6.--Cut terminals in pairs from the strip of terminals and place on one side of the glass plate. Cut as many pairs as are needed.

Step 7.--Remove one of the plastic envelopes containing one strain gage from the package of five strain gages. Open this plastic envelope, and with clean, pointed tweezers, carefully move the gage so the epoxy backing extends out of the envelope. The gage grid should be positioned one-sixty-fourth inch inside the plastic envelope (fig. 2).

Step 8.--With clean scissors, cut the epoxy backing that extends out of the plastic envelope. Use this envelope as a guide when cutting. If the strain gage is not packaged in a plastic envelope, cut the epoxy backing off about one-sixty-fourth inch from the gage grid. Repeat this procedure for as many gages as needed.

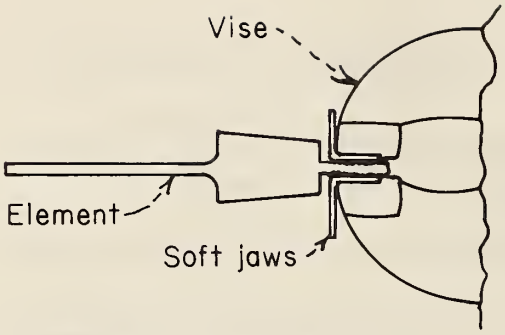

FIGURE 1. - Tapered fit transducer.

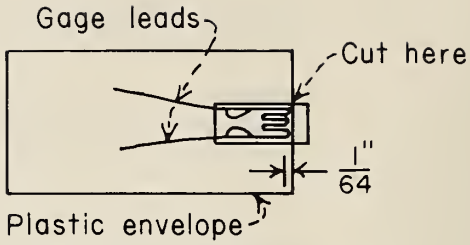

FIGURE 2. - Trimming the strain gage.

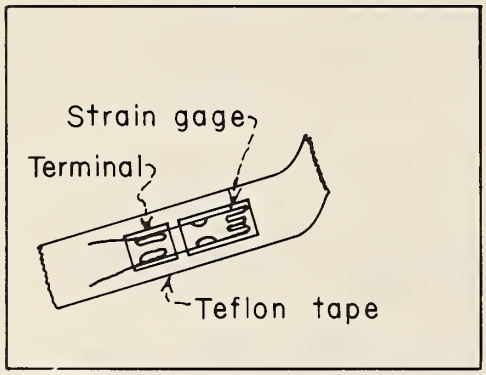

FIGURE 3. - Handling the strain gage and terminal.

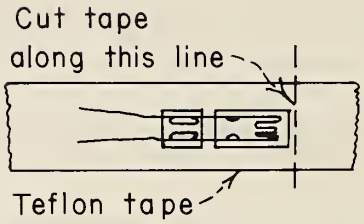

FIGURE 4. - Preparing the strain gage for placement on the element.

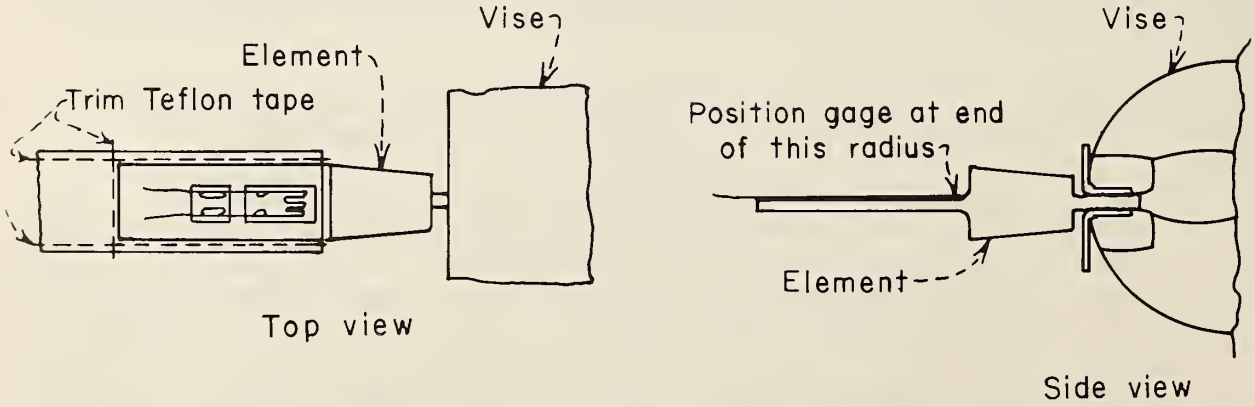

FIGURE 5. - Placing the strain gage on the element.

Step 9.--Remove the gage from the plastic envelope with pointed tweezers and place it on the clean glass plate with the shiny side of the gage up. Do not clean the gage unless it is touched. If the gage is touched, clean the back of the gage by wiping with a cotton-tipped applicator moistened with trichloroethylene; if the gage touches the floor, clean with neutralizer.

Step 10.--Place one pair of terminals about one-thirty-second inch behind the gage.

Step 11.--Place a piece of Teflon tape one-half inch wide and about 1-1/2 to 2 inches long over the terminals (fig. 3). Do not use transparent tape, which will contaminate the gage installation and, when heated, will adhere to the gaging surface. While holding one end of the tape, pick up the gage and terminal by peeling the tape from the glass plate at about a 30° angle.

Step 12.--Cut the Teflon tape off about one-thirty-second inch beyond the trimmed end of the gage (fig. 4). This one-thirty-second inch of tape will help to hold the strain gage to the element after the adhesive has been applied.

Step 13.--Place the trimmed end of the gage on the element (fig. 5). Center the gage and terminal along the axis of the element. Press the Teflon tape in back of the terminal firmly against the element with the dental probe. Trim excess tape from the side and back.

Step 14.--Rotate the element 180° using heavy tweezers and repeat steps 9 through 13. Select a strain gage that has been marked (Micro-Measurements' Option RR) with the same resistance as the gage used on the opposite side. Closely matched gages lessen the effect of temperature on the circuit.

Step 15.--Spring clamps are recommended for holding the strain gages to the element during heat-curing; however, a lathe dog clamp, with 1/8-inch-thick felt pads cemented to the jaws and covered with nonadhesive Teflon sheeting, may be substituted. With the lathe dog clamp, two elements can be heat-cured at a time. (A C-clamp should never be used since it may loosen when heated.)

Have Teflon pads and metal backup blocks on hand along with the spring clamps. The metal blocks should be thick enough that the jaws of the spring clamp will be parallel (see fig. 6). This is necessary to have the force perpendicular to the surface of the strain gage; otherwise, the strain gage may move out of position on the uncured adhesive.

Step 16.--Prepare the adhesive according to the instructions provided by the manufacturer. If a lathe dog clamp is being used, secure this clamp in a large vise at this time. Adjust the tension of the springs to produce a pressure of 40 to 50 psi. If spring clamps are used instead of the lathe dog clamp, proceed with step 17.

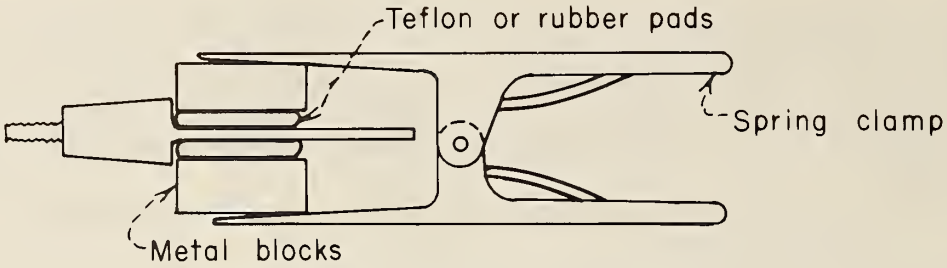

FIGURE 6. - Clamping technique.

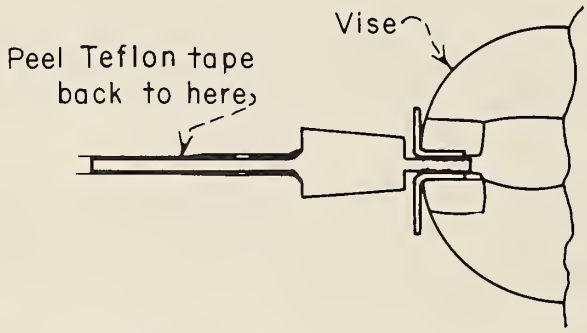

FIGURE 7. - Preparing the element for epoxying the strain gage and terminal.

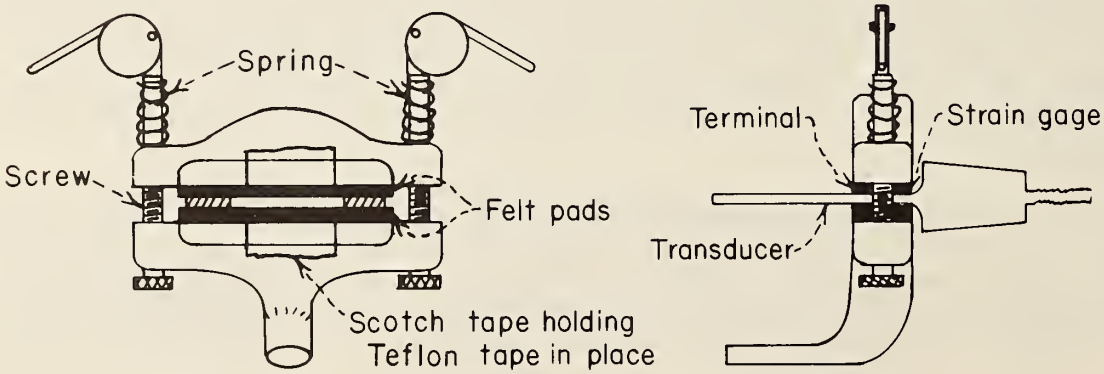

FIGURE 8. - Lathe dog clamp showing element location for heat curing.

Step 17.--Place the threaded end of one of the prepared elements in the vise. Pick up the gage and terminal from the surface by peeling the tape back

from the threaded end of the element (see fig. 7). With a dental probe, spread a very thin (about 0.001 inch thick), even coat of adhesive over the gaging area. Make sure the area is completely covered. Push the terminal and gage down on the surface by rolling the thumb over the gage, or roll a dental probe carefully over the area. Check for gage alinement and be sure that the gage has adhered to the surface. If the gage has "popped up," rework the adhesive with the dental probe and press the gage down again, using the same method.

Step 18.--Rotate the element 180° in the vise and repeat step 17.

Step 19.--With the element still in the vise, lay a Teflon or rubber pad over the gage and terminal. Place the metal backup block over the pad. Hold another pad and metal backup block in place on the underside of the element. Set the spring clamp (fig. 6).

If the lathe dog clamp is used, set aside the prepared element and place another element in the vise. Prepare this second element (steps 17 and 18). Take both elements to a second vise, which is holding the lathe dog clamp, and place one element on each side near the screws (fig. 8).

Step 20.--Place all elements that have gages clamped on in an oven at ambient temperature and raise the temperature at a rate of 5° to 20° F/min (10° F/min is preferred) to the desired temperature. At the end of the curing cycle, turn the oven off, leaving the elements in the oven until cooled.

Step 21.--Take the assembly from the oven and remove the elements from the clamp(s). Remove the Teflon tape by peeling it back directly over itself with a slow, steady pull. If tape residue remains, clean the gage and terminal with acetone. Clean any excess adhesive from the gage with a sharp knife (excess adhesive may cover the front of the gage at the radius of the transducer or the side of the transducer). Extreme care must be taken so as not to cut the gage when removing the cured adhesive.

Step 22.--Cut the lead wires coming from the strain gage about one-third of the way down on the terminal (see fig. 9), and bend them back about 90°. Do this on both sides.

Step 23.--A soldering station or a temperature-controlled soldering iron should be used. A chisel point one-sixteenth inch wide in the soldering iron is recommended.

a. With a fresh ball of solder (use only rosin-type soldering fluxes) on the soldering iron, tin the lead wires on both sides of the transducer.

b. To obtain a good solder dot (a shiny ball of solder) on the terminal, position the solder on one end of the terminal and place the clean soldering iron on the solder. A solder dot should form. Do this to the other end of the terminal and the adjacent terminal. Rotate the transducer 180° and place four more solder dots on the terminal.

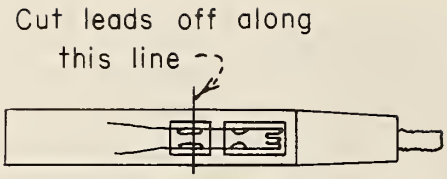

FIGURE 9. - Cutting strain-gage wires to the correct length.

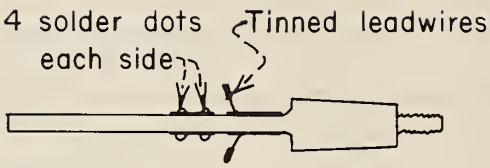

FIGURE 10. - Transducer showing solder locations.

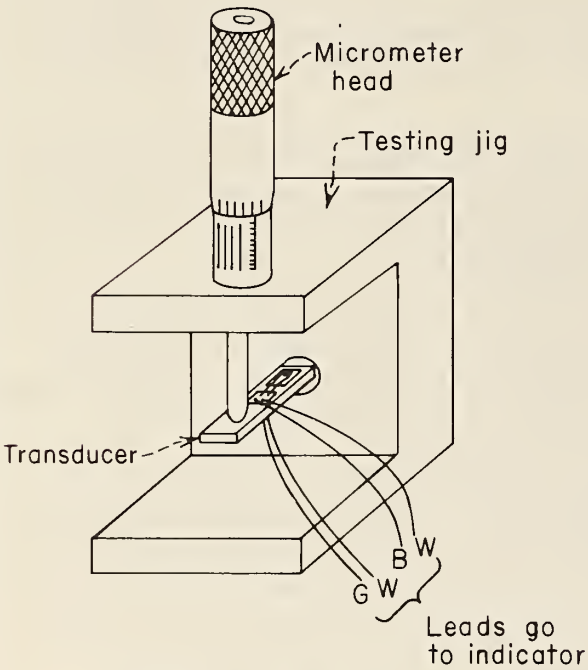

FIGURE 11. - Test jig assembly.

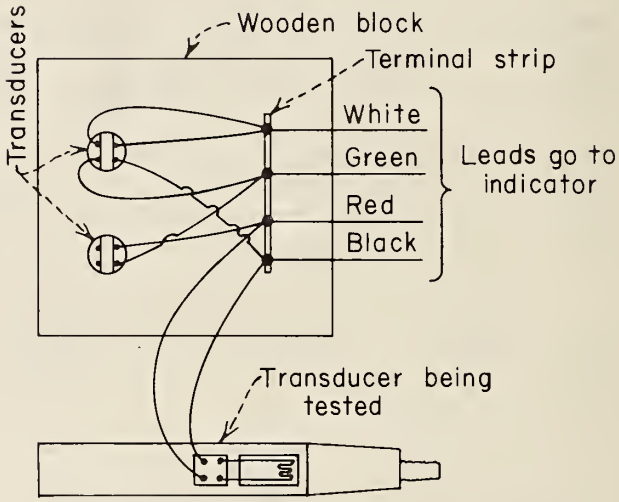

FIGURE 12. - Apparatus for testing transducer resistance.

(see fig. 10). (If the solder sticks to the iron and forms a point, the iron is too hot.)

c. Bend the lead wire down on the solder dot and hold in place with slight pressure, using a wooden toothpick or dental probe. Touch the lead wire and solder dot with the clean soldering iron (use the flat part of the chisel point). When the solder dot liquefies, the lead wire under pressure will drop into the solder dot. Remove the iron and allow the solder to cool. Release pressure from the lead wire.

d. Clean the terminals and leads by brushing on rosin solvent and blotting dry.

e. Prepare all the transducers using this procedure.

Step 24.--Use an ohmmeter to check each strain gage on the transducers for short circuits and continuity.

Step 25.--Place the transducer in a testing jig[5] (see fig. 11) and test it for creep. The tapered hole in the jig has the same dimensions as the hole in the borehole gage body.

a. Pull the transducer into the tapered hole by tightening the transducer nut in the back. A micrometer head is screwed into the threaded hole in the top of the jig. If the micrometer head is not threaded, use a set screw to hold the micrometer head in place.

b. Solder four wires to the terminals of the transducer and connect the other ends of these wires to a strain indicator. Balance the strain indicator, using a gage factor of 0.40.

c. Turn the micrometer until it contacts the transducer. Contact is made when the strain indicator needle moves.

d. Deflect the transducer by turning the micrometer head 0.016 inch. Record the strain reading on the indicator.

e. Take readings every 5 min for 30 min. The total creep after 30 min should not exceed 50 μin/in. Transducers with more than 50 μin/in creep in 30 min should be postcured. This is done by heating the transducer for 4 or more hours at 120° F (49° C), or 1 hour at 200° F (93° C).

f. Repeat step 25 for postcured transducers.

Step 26.--Although resistances of the strain gages have been matched to within 0.01 ohm, clamping pressure, glue thickness, and soldering can change the resistance; therefore, the installed strain gage resistance must be rechecked. This is done by mounting two transducers on a board. Wire them in a four-arm bridge, but leave one side of one transducer (two wires) out of the circuit. These two wires are soldered to one side of the transducer being tested, as shown in figure 12. This completes the four-arm bridge. The four main wires are connected to a strain indicator. Balance the indicator and record the reading as side "a," transducer 1. Unsolder the strain gage, and solder the two leads to the strain gage on the opposite side of the transducer. Balance the indicator and record this reading as side "b," transducer 1. Do this to all transducers.

---

[5]A blueprint of this testing jig is available from the Bureau of Mines, Denver Mining Research Center, Building 20, Denver Federal Center, Denver, Colo. 80225.

Transducers having the same or nearly the same ratio of side "a" to side "b" strain readings are paired. For example, if the strain readings of side "a" of transducers 1 and 2 are close in value and side "b" of transducers 1 and 2 are close in value, the following arrangement is used: With side "a" of transducer 1 positioned to face outward (side of transducer with which the piston makes contact), side "b" of transducer 1 will face inward toward the center of the gage. Side "b" of transducer 2 will face outward, and side "a" of transducer 2 will face inward. As the transducers are paired, the ratio between the strain readings of the remaining transducers will increase.

Step 27.--Transducers are now ready to install in the borehole gage body. Three pairs of transducers should be selected for each gage.

PART 2.--ASSEMBLING THE THREE-COMPONENT BOREHOLE GAGE[6]

Materials

The following list of materials will be needed to assemble the three-component borehole gage. Obtain all the components before starting the assembly.

Cable--A shielded eight-conductor cable with No. 18 wire and neoprene jacket (0.42 inch OD), and about a 100-foot length is needed. Alpha No. 1456 cable is currently used by the Bureau, but an equivalent cable can be substituted.

Connector--An eight-pin connector, preferably with gold-plated pins, no larger than five-eighths inch in diameter is needed to connect the cable to the borehole gage. Nine-pin Amphenol connectors are presently being used. The female socket connector (Amphenol No. 126-013) will be screwed into the borehole gage body. The male pin connector (Amphenol No. 126-220) is soldered to the eight-conductor cable; however, the shell of the connector must be reamed to fit over the cable.

Hookup wire--No. 30 stranded-wire thermoplastic insulation in eight different colors (the colors should match those of the eight-conductor cable) will be needed.

Transducers--Three matched pairs.

Transducers locking nuts--Six required.

Borehole gage case.

Borehole gage placement end.

---

[6]Drawings of the borehole gage and special tools are available from the Bureau of Mines, Denver Mining Research Center, Building 20, Denver Federal Center, Denver, Colo. 80225.

Clamping nut.

Rubber grommet--Crouse-Hinds No. 93 fits inside the clamping nut and back of the borehole gage case.

Concave washer--Positioned between the clamping nut and rubber grommet.

Pistons--Six required, but should have two spares.

Piston washers--Fit on the piston. Should have two thicknesses, 0.005 inch and 0.015 inch (about 36 0.005-inch washers and 12 0.015-inch washers).

O-ring--"Buna" No. 2-213 for the borehole gage body and No. 2-009 for the piston.

Screws--Sixteen 4-40 stainless steel flat-head machine screws, one-quarter inch long, to fasten the borehole gage case and borehole placement end to the borehole gage body. Three 2-56 stainless steel slotted pan-head machine screws, three-sixteenths inch long, to hold the wire spring secure in the borehole gage placement end.

Wire--No. 23 music wire (0.051 inch in diameter) to make three springs for the borehole gage placement end. The springs center the borehole gage in the 1-1/2-in-diameter borehole.

Connector placement tool--A brass rod with nine pins that fit into the nine sockets of the female connector.

Special wrench--Made from tool steel with a square milled on one end of the rod to fit into the milled squares on the transducer locking nut.

Description of Borehole Gage Assembly

These instructions should be followed for assembling the borehole gage and for conducting the tests needed to insure that it is functioning properly.

Step 1.--Cut 24 pieces of hookup wire, approximately 3-1/2 inches in length. Use six black, six green, and two each of the remaining six colors. If it is decided to use the Amphenol connectors, the following color code should be used: A--black; B--orange; C--brown; D--blue; E--yellow; F--green; H--red; J--white. The pin on the connector marked "K" is not used. (This color code may not apply to other manufacturers' connectors.)

Step 2.--Tin the terminal pins on the female socket connector.

Step 3.--Twist the same-colored hookup wires together and solder. It may be necessary to trim the green and black wires (since there are six individual wires) after they are soldered to fit into the terminal of the connector.

Step 4.--Solder these wires to the terminal pins of the female socket connector, following the color code given in step 1 if the Amphenol connector is used.

Step 5.--Tape the ends of those wires together with drafting tape as shown in figure 13.

Step 6.--Squeeze translucent silicone rubber adhesive (General Electric RTV-108 or Dow-Corning 732 RTV) into the terminal pins until all the soldered connections are covered. Do not extend any of the adhesive past the threads of the socket connector. Dry for 24 hours.

Step 7.--Wrap ribbon dope (a tape that is wrapped around threads for sealing) around the threads of the female socket connector.

Step 8.--Insert a connector placement tool into the female socket connector. With this tool, push the taped wires through the center hole of the borehole gage body and screw the socket connector firmly by hand into the recessed, threaded hole in the borehole gage body. Remove the drafting tape from the wires.

Step 9.--Position the 24 wires in the order needed for soldering to the transducers as shown in figure 14. Some wires will have to twist around others.

Step 10.--Select one pair of transducers and insert one of these transducers into the borehole gage body. Start the transducer locking nut on the threads of the transducer. Position the transducer with the proper side (see step 26 in the "Description of Strain Gage Installation" section) facing out and tighten the nut with the special wrench. Position the second transducer in the borehole gage body opposite the first transducer. Use this procedure to assure alinement of transducer motion with piston motion:

a. Place a small 90° triangle at the top and against the inside face of the second transducer with the perpendicular side of the triangle at the edge of the transducer.

b. Keeping the triangle fixed on the flat side of the transducer, rotate the triangle and transducer until the triangle edge is in line with the edge of the opposite transducer and tighten the transducer nut.

c. If necessary, loosen the nut of the first transducer and repeat the alinement step. These two transducers will be one of the three components.

Step 11.--The 24 wires in the borehole gage body are cut off about one-quarter inch shorter than the transducer. These ends are now stripped and tinned.

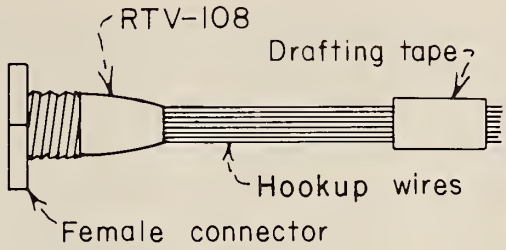

FIGURE 13. - Female connector and hookup wires.

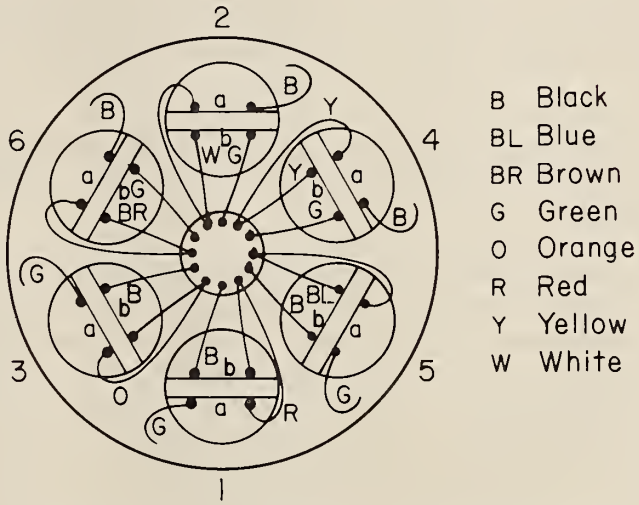

FIGURE 14. - Transducer location and color code.

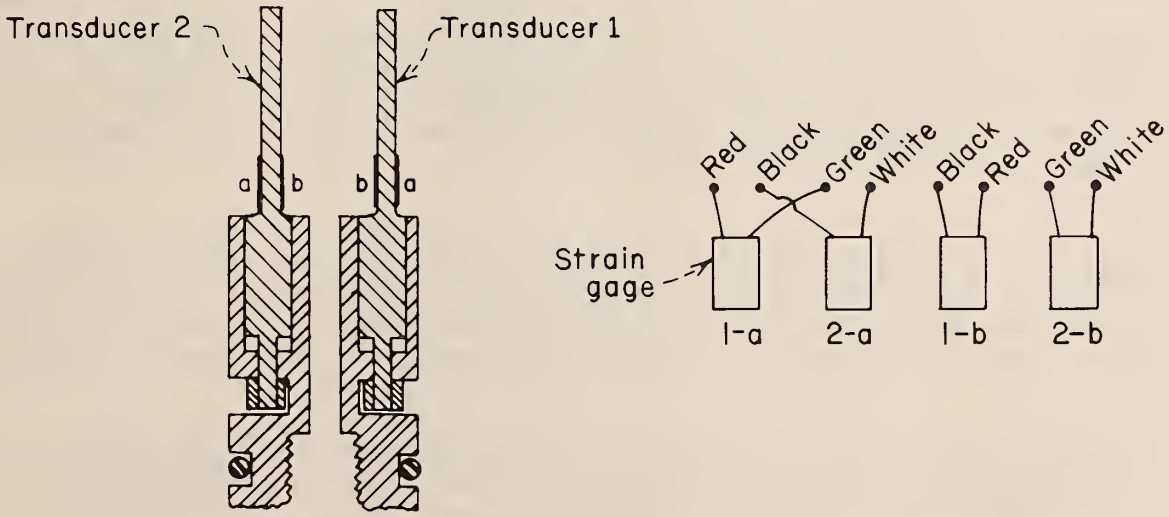

FIGURE 15. - Wiring diagram for one component in the three-component borehole gage.

Step 12.--Solder two of the black wires, two of the green wires, the two red wires, and the two white wires to these transducers. This will be component 1. Figure 15 shows the color code for wiring the transducers into the three components.

Step 13.--Position the next pair of transducers opposite each other in the borehole gage body. Repeat step 10. Figure 14 also shows the transducer location in the borehole gage. Two of the black wires, two of the green wires, the two orange wires, and the two yellow wires are soldered to these transducers. These two transducers are component 2.

Step 14.--Position the last pair of transducers in the remaining two holes in the borehole gage body, but do not tighten the transducer locking nut. Due to the limited space between the transducers, these two transducers may have to be turned so the inside wires can be soldered. Solder the four remaining green and black wires, the two blue wires, and the two brown wires to the transducers to complete component 3. After soldering, turn the transducers back into position, check with the 90° triangle (step 10), and tighten the transducer locking nuts.

Step 15.--Fully encapsulated strain gages are recommended because moistureproofing is not needed with this type of gage. If this type of encapsulated strain gage is not used, a high-quality moistureproofing material should be used over the strain gage and soldered terminals. In any case, the soldered terminals should be covered with some kind of moisture protection. Before the soldered terminals are covered, they must be cleaned by flooding the area with rosin solvent and blotting dry. Do not let the rosin solvent air-dry. Various types of moistureproofing materials are available from the strain gage companies. Beeswax can be used to cover the soldered terminals. Before moistureproofing is used on the strain gages and/or the soldered terminals, heat the gage to 120° F for 1 hour or more to insure that no moisture is trapped beneath the moistureproofing.

Step 16.--The terminal pins are lettered in a clockwise order when looking at the back (terminal pin end) of the male pin connector. Select the end of the eight-conductor cable with the color wires black, orange, brown, blue, etc., arranged counterclockwise. Position this end of the cable at the back of the pin connector; the order of the cable wires will follow the order of the terminal pins.

Step 17.--Cut about one-half inch of neoprene jacket and shielding from the cable end. Separate the eight individual wires. Strip these wires as far back as possible and tin the ends. Cut the tinned wires off, leaving no more than one-eighth inch. They may also have to be trimmed to fit into the terminal pins.

Step 18.--Slip over the eight-conductor cable in the following order: A borehole gage placement end; clamping nut; washer; rubber grommet; and the reamed-out shell of the male pin connector.

Step 19.--Tin the terminal pins of the male pin connector and solder the cable to the connector in the order stated in step 1.

Step 20.--Squeeze RTV-108 or an equivalent silicone rubber adhesive on the female socket connector (step 6). Turn the shell onto the connector before the silicone rubber adhesive dries. Dry for 24 hours.

Step 21.--Trim about 15 inches of jacket and shielding off of the other end of the eight-conductor cable. Separate the wires and strip about one-half inch of insulation from each wire. Tin these ends. This end of the cable will be connected to the strain indicators or switching unit.

Step 22.--Connect the cable (end with the male pin connector) by plugging it into the borehole gage body, and test for short circuits between the cable and the gage.

Step 23.--Connect the cable to three strain indicators, or a three-channel switching unit and one strain indicator. If three strain indicators are used, two auxiliary wires are needed to furnish common excitation (black and green wires) to the borehole gage from the three indicators. Balance the three indicators, representing the three components. When three indicators are used, lightly squeeze together one pair of transducers and observe the other two strain indicators. The needles should move only slightly or not at all. If the needles move a minor division or more, one or more of the hookup wires is lying against a transducer(s) and must be pulled away. The other two components must also be checked. When only one strain indicator is used, gently squeeze each of the other two pairs not hooked to the strain indicator and observe the needle. Repeat for all combinations of transducers.

Step 24.--The borehole gage is now assembled. File a notch on the front rim of the borehole gage case above the number 1 transducer to denote component 1. This is used to correctly orient the borehole gage in the 1-1/2-in-diameter borehole. The axis passing through the orientation pins on the borehole gage placement end must be perpendicular to the notch in the borehole gage case. Place the pistons in the gage. Be sure to use a silicon grease (Dow Corning 44 or an equivalent) on the cable where it passes through the rubber grommet, the O-ring on the borehole gage body, and the O-rings around the pistons.

Step 25.--Connect the borehole gage to the strain indicators and place the gage in a container of water. Record the readings after the gage is placed in the water and again about a day later. If the indicator needle has moved off-scale or the strain indicator(s) cannot be balanced, water has entered the gage and the leak must be located. In most cases, the holes that were drilled for the gage screws went through the gage body. If this is the case, these holes must be sealed. This can be done by putting an epoxy (like Armstrong) or plastic steel into the bottom of the screw holes in the gage body. After this filler is cured, chase the threads with a 4-40 bottoming tap. Assemble the borehole gage and recheck.

Recommendations

The three-component borehole deformation gage is now ready for calibration (5) and use. It is advisable, when using the borehole deformation gage for in situ measurements, to calibrate the gage before, and upon completion of the field work. This insures that the borehole gage is functioning correctly.

From past experience, it is strongly recommended that Bureau of Mines Information Circular 8618 (5) be read thoroughly before undertaking any in situ measurements with the three-component borehole deformation gage.

REFERENCES

1. Becker, R. M. An Anisotropic Elastic Solution for Testing Stress Relief Cores. BuMines RI 7143, 1968, 15 pp.

2. Becker, R. M., and V. E. Hooker. Some Anisotropic Considerations in Rock Stress Determination. BuMines RI 6965, 1967, 23 pp.

3. Fitzpatrick, J. Biaxial Device for Determining the Modulus of Elasticity of Stress-Relief Cores. BuMines RI 6128, 1962, 13 pp.

4. Hooker, V. E., J. R. Aggson, and D. L. Bickel. Improvements in the Three-Component Borehole Deformation Gage and Overcoring Techniques. BuMines RI 7894, 1974, 29 pp.

5. Hooker, V. E., and D. L. Bickel. Overcoring Equipment and Techniques Used in Rock Stress Determination. BuMines IC 8618, 1974, 32 pp.

6. Hooker, V. E., D. L. Bickel, and J. R. Aggson. In Situ Determination of Stresses in Mountainous Topography. BuMines RI 7654, 1972, 19 pp.

7. Hooker, V. E., and C. F. Johnson. Near-Surface Horizontal Stresses Including the Effects of Rock Anisotropy. BuMines RI 7224, 1969, 29 pp.

8. Merrill, R. H. Three-Component Borehole Deformation Gage for Determining the Stress in Rock. BuMines RI 7015, 1967, 38 pp.

9. Merrill, R. H., and J. R. Peterson. Deformation of a Borehole in Rock. BuMines RI 5881, 1961, 32 pp.

10. Obert, L. Triaxial Method for Determining the Elastic Constants of Stress Relief Cores. BuMines RI 6490, 1964, 22 pp.

11. Obert, L., R. H. Merrill, and T. A. Morgan. Borehole Deformation Gage for Determining the Stress in Mine Rock. BuMines RI 5978, 1962, 11 pp.

12. Panek, L. A. Calculation of the Average Ground Stress Components From Measurements of the Diametral Deformation of a Drill Hole. BuMines RI 6732, 1966, 41 pp.

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